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AUTHOR Manzo, Anthony V.
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ABSTRACT

In an examination of the problem of national mathematical illiteracy, the math student, the math teacher, and the math problem are discussed. The math student may have defects, deficiencies, disruptions, and/or differences in the cognitive abilities required to perform a mathematical problem. The math teacher may tend to be less verbal and less socially responsive than other teachers. Math teachers also may have internalized mathematical reasoning and its accompanying numerical coding and notation so that they can hardly understand the primitive state of most students and many adults and thus students tend not to question, but instead accept math as a closed system. The math word problem poses a barrier to learning because of the new words and notations and the complex language and terse sentences. An approach to these problems which involves the student, the teacher, and the problem is the R/Q procedure, a variation of the ReQuest procedure developed by Manzo. The R/Q procedure is a questioning strategy carried out between teacher and student in which they both read each sentence of the problem and then ask each other questions about the problem until the student is ready to solve the problem. (MKM)

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The Math Student/The Math Teacher/The Math Problem[1]

Anthony V. Manzo, Reading Center
School of Education
University of Missouri - Kansas City

The difficulties experienced by students in dealing effectively with "word" problems and related math concepts is unparalleled among current educational dilemmas; it is also among the lowest ranking of national priorities. There are more computational morons and math illiterates than there are people who cannot read. Further more, there are many who can read and language effectively, but who are relatively incompetent to deal with simple math concepts, fundamental computation, and even the simplest of life problems requiring the use of mathematics. The numbers of people in these categories exceed the combined magnitude of the number who have been called "culturally deprived," those called "learning disabled" and, as suggested above, those labeled "functionally illiterate." Weakness among citizens in dealing with math concepts, computation and word problems is so endemic to the society that it tends to be accepted as an environmental fact; and as such is an understandable loser in the national competition for our problem-solving resources.

It is the intent of this paper to garner wider interest in this problem by explicating areas of the situation intended to pique the interests of professionals in and peripheral to math education. Assistance from the latter groups especially reading/language arts specialists and learning psychologists, is needed to extend the reach of examination to new dimensions from which alternate approaches to resolution may be generated.

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[1] Paper presented to the Missouri Council of Teachers of Mathematics, October, 1975.

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To these ends, three zones suggest themselves for exploration: the Math Student, the Math Teacher (and his teaching), and the Math Problem.

The Math Student

. A non-math world - Students live in a non-mathematical world. The functions and the language of math are hidden. Therefore, a major source of "incidental" learning is obliterated. Incidental learning is a non-specific but fundamental and hidden curriculum which establishes a student's "readiness" for subsequent systematic instruction. "Readiness programs," while helpful, cannot equal the impact of an environment rich with opportunity for incidental learning experiences. It is for this reason that in an analogous realm, viz, reading instruction, even the most carefully constructed "readiness" programs have failed to insure success in reading for disenfranchised students as compared with the incidental preparation typical to middle class life.

. Math appears esoteric - As by-product of the first observation, plus the fact of low utility, math appears to most students as esoteric and unrelated to the requirements of daily living; which in fact for the most part it is. It simply is not on a par with social studies and life sciences for popular appeal and utility.

. Solving math problems is perceived as a perfunctory activity - Both of the conditions stated above participate in this condition. It is a long established fact that problem solving involves intellectual tension, with a resultant rise in dissonance, and dramatic as it may seem, the consumption of life's limited energies. The reinforcement for permitting dissonance to occur comes in the form of a satisfied feeling accompanying release from tension. This is not achieved as a full cycle for many who attempt math word problems due to the fact that a) they frequently fail to solve the problem, b) the problem does not appear sufficiently relevant to warrant the discomfort, c) the realization that the answer is already known makes the entire experience appear idle and perfunctory.

. Many students are impeded by defects, deficiencies, disruptions and/or differences where math is concerned. These four "D's" are useful diagnostic models recommended by Weiner and Cromer (1967) for examination of reading difficulties. It is a simple and therefore easy fact to overlook that mathematics is a form of abstract reasoning which challenges the limits of intellectual abilities. In this respect, many must be said to be frankly defective, in the sense of being constitutionally unable to learn easily and effectively. Others likely have deficiencies, missing subskills or weak areas of cognitive ability which impeded their progress. Still others suffer disruptions, or conditions which sharply impede abstract reasoning. Chief among these are emotional interlopings caused by high levels of anxiety or impulsivity. Finally, there are those students who are tempermentally incompatible with mathematical operations; they have a cognitive style which is different from the requirements of mathematics. It has even been suggested that left-hemispheric brain dominance, which is most predominant, tends to orient cognition toward verbal operations as opposed to mathematical ones.

The Math Teacher (and his teaching style)

. Math teachers have counter-effective peccadilloes. They tend to be less verbal and less socially responsive than other teachers. The math teacher is not given to excesses, he reserves his passion. He is a long-distance runner; a singles tennis player; a chess enthusiast. He prefers cerebral to social activity. He is committed to order, control and structure. He also appears judgmental and socially distant. These features are at odds with youthful exuberances and excesses. The resulting lack of empathy between most students and their math teachers is generalized to the subject of math, which in fundamental ways is also incompatible with youth.

. The math teacher, in a manner of speaking, is too smart - The math teacher has so internalized the vagaries of mathematical reasoning, and is so comfortable with numerical coding and notation that he can hardly understand the primitive state of most students and many adults. Knowing as he does more than even the adults about him, the math teacher develops a very understandable sense of superiority (as do others, such as English teachers and editors). Add to this the basically non-verbal nature of the math teacher, his lesser degree of social responsiveness, and the students' impression that the math teacher is distant, and the result is a still classroom. The most frequent sound is the teacher's erstwhile query, "any question?", to which students internally respond - "she must be kidding, I don't even know what to ask."

. Math is taught as a closed system. Mathematics as taught in school does not invite curiosity and inquiry. The answers are in the back of the book. Further, the math teacher came to his interest in math primarily because it was orderly and predictable, thus he tends to represent it as a finished product rather than as an open, scientific system of coding and life problem-solving. This condition suggests a paradox with the above observation, that the math teacher knows too much, because his inability to present mathematics as viable suggests that he does not know it quite well enough.

. The new math is a new contrivance; and little more. The "new math" with its "distrubtive," "commutative" and "associative" properties is reminiscent of another educational monster which we are still struggling to divest ourselves of, namily grammar lessons, with their "verbals," "gerundives" and "adjectivals." Neither good speech nor good "math sense" are products of lessons in the skelital structures of the disciplines. Good language is an extension of dynamic examination of life environments and incidental conditioning to good language

patterning in a mileu rich with emphatic models of the desired behaviors. So too, is mathematical sense likely to develop. New math attempts to teach math language and math concepts, but these only have meaning, as an outline has meaning, when preceded by experience and knowledge for which it serves as organizer and reminder. The ideas and language of new math may be fundamental properities of mathematics, but they are neither simple nor useful ideas in learning math. This is not to say that they are totally useless. They probably have a utility analogous to the impact on reading skills gained when a student is taught to label and discriminate diphthongs from diagraphs.

The Word Problem

. New words and notation are a new language. The notations and language of math create massive levels of symbolic confusion and obfuscation. It is comparable to learning a new language, and having to learn from it at the same time. Here is a typical line from a 5th grade workbook, "to find the product of 3 + 242, you can apply the distributive property as shown at the right." The expressions "product of" and "distributive property" are new language, they account for nearly 20% of the words in this short, declarative sentence. That, by any reasonable definition is frustration level reading.

. Complex language and terse sentences. Even when all the words are known, the language of math is terse, uninspirational and/or syntactically overwhelming. Here is a sentence, again from a fifth grade book, demonstrating the level of joylessness and terseness which can be found in even a simple sentence without so much as a comma splice. "One way to find the least common multiple of two numbers is to list the multiples of the greater number until you find one that is also a multiple of the smaller number." This is unconscionable use of

language in school texts.

. The word problem offers little context to justify itself. A student can be led to read and comprehend complex social and economic problems because his social studies book attempts to meet him where he is and to lead him from the point of a personal concern to a magnification of that understanding to higher plains of abstraction and generalization. The problems found in a math book are the bottom lines of long but unexplicated stories. Further, mathematical systems are answers to questions which students have not been led to raise. It is this fact, perhaps more than any other, which renders math and many things associated with it to appear superfluous, arbitrary, intimidating, and to many, punishing.

Only a Balm Can Solve These Problems

The breadth and depth of the situation which culminates in the question "why can't students read math word problems?" will require time and thought to unravel. It is evident, however, that the resolves will need to include a balm - an anointment to heal and soothe the sense of being put upon that most people feel when they meet a math book, and, to an extent, a math teacher.

The balm will undoubtedly be constituted of certain predictable ingrediants. Undoubtly it will include a pulverization of existing math books and the construction of new ones which are less pedantic, and which talk, and welcome conversation back. There will also be need to extend the utility in the language of math into the language arts and social studies; this to make the vocabulary of math more a part of our daily community of words, and also, to humanize a language system which, with the exception of the googol,* is unappealingly antiseptic. The reason, purpose and value of mathematical systems also need to be explicated so students might understand what the question is that

*a googol is the largest number with a name, it is the equivalent of saying a million, million

the construction of an equation presumes to answer. Too, teaching strategies need to be devised which have the math teacher and student engage in a reciprocal interaction, one permitting them to influence and be influenced by one another in positive and empathetic ways.

In the latter category, we offer the R/Q procedure, an approach under development by Professor William C. Smith of mathematics education and the author. The technique as currently envisioned is a variation on the ReQuest Procedure (Manzo, 1969), a simple strategy for improving comprehension.

The R/Q Procedure

. A strategy for improving comprehension of word problems - A reciprocal questioning strategy carried out between teacher and student, R/Q is designed to teach the language of math, a system of mathematical inquiry and word problem solving. The teacher serves as a model of questioning, language and thinking behavior.

Strategy

Teacher explains the rules and purpose(s) of the R/Q interaction, which are as follows:

1. Both teacher and student read the first sentence of a word problem silently.

2. The student is directed to ask the teacher any and all questions which he chooses to about that sentence. The student should try to ask questions which he thinks the teacher might ask of him, even if he does not have a pressing question in his mind at that moment.

   a) The teacher answers all questions fully, eschewing the inclination to tell the student more than he may want to hear.

   b) The teacher helps the student to better frame his questions so that they are cogent, answerable and contain some math-like language. (The teacher must make a special effort not to answer questions with questions).

3. When the student has asked all the questions he wishes to ask, the teacher may now ask the student as many as he wishes. Questions should be directed primarily to establishing literal comprehension. Questions of the recall, recognition and translation type should be stressed.

4. Reciprocal questioning continues through each sentence of the word problem.

5. Questioning should be directed to each of three areas, in sequence:

   a) What does the problem say(?)

   b) How is the problem best organized-translated into math notation to be solved(?)

   c) What computations must be done and in what order(?)

Optional:

   d) How is the computation done(?)

   e) How can the answer be verified(?)

The above should be preceded by the student having independently attempted to solve a word problem of the type analyzed through the R/Q interaction

Efforts to further shape the above procedure are in progress. One variation suggested from recent experiences deserves immediate inclusion. It is for those situations where the student is having extreme difficulty in asking questions, or where the teacher finds himself unable to overcome his own prior conditioning, as when he answers questions with questions, regularly uses difficult technical language, or otherwise simply intimidates the student by appearing unexplainably imposing. The variation has the student and teacher asked one another just one question each at a time. When the student ceases to raise questions, he must solve the problem.

Current efforts are limited to one-on-one teaching, it is anticipated, however, that the procedure will be equally viable with groups of students.

The teacher could select, from volunteers, the student to raise or answer a question, until every student had exhausted his option.

Additional possible variations and a data based assessment of the efficacy of the procedure will be forthcoming. We welcome critiques, anecodatal accounts and suggestions.

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